

8. MONITORING AND BMP EVALUATION (JULY 14, 2010)

8.1 Introduction

This section presents a summary of the San Diego Hydromodification Management Plan's (HMP's) revised Monitoring Plan. The summary explains technical concepts and proposes approaches to monitor the effectiveness of the HMP as required by provision D.1.g of Regional Board Order No. R9-2007-0001.

Part 1(k) of provision D.1.g requires that the HMP shall "include a description of pre- and post-project monitoring and other program evaluations to be conducted to assess the effectiveness of implementation of the HMP". For the purposes of developing an HMP monitoring approach, an effective HMP is defined as a program that ensures compliance with HMP design criteria and results in no significant stream degradation due to increased erosive force caused by new development.

The proposed monitoring approach provides for the optimum 5-year effectiveness assessment within currently available funding resources. Monitoring Plan activities were selected to achieve statistical data collection requirements while balancing regional financial constraints and highly variable scientific, regulatory, and physical elements. Monitoring plan activities presented herein have been developed to answer the following questions regarding HMP program effectiveness assessment:

- **Do field observations confirm that the HMP appropriately defines the flow rate (expressed as a function of the 2-year runoff event) that initiates movement of channel bed or bank materials?**
Since most of the sediment transport modeling prepared as part of the HMP development relied on laboratory flume data, it is important to supplement the sediment transport data set with field observations. This data may be used in the next permit cycle to determine whether critical shear stress is the appropriate parameter for selecting the lower flow threshold of the geomorphically significant flow range.
- **Are mitigation facilities adequately meeting flow duration design criteria outlined in the HMP?**
Observed HMP mitigation facility outflow data can be analyzed to determine if mitigation facilities are reducing the mitigated post-project peak flow frequency and flow duration curves to the pre-project curves (within tolerances set forth in the HMP). This data can also be used to analyze the precision of Low Impact Development (LID) sizing factors, extended detention facility design criteria, and to potentially recommend changes to more closely match the mitigated post-project curves to pre-project condition peak flow frequency and flow duration curves.
- **What is the effect of development on downstream cross section incision and widening?**
Since the mitigation of accelerated channel degradation as a result of development is the central purpose of the HMP, analysis of channel cross sections downstream of development projects is a component of the monitoring plan. However, uncertainties involved with this comparison tool (namely the determination of pre-project condition trends regarding channel incision and channel widening rates) make policy determinations less likely within the time frame of the 5-year monitoring plan (as compared to sediment transport modeling and flow duration modeling detailed in the previous two questions).

Such a question-driven plan is consistent with the draft hydromodification monitoring framework prepared by the Southern California Coastal Water Research Project (SCCWRP – report dated December 9, 2009).

In an effort to effectively address the wide variability of potential monitoring scenarios and competing needs outlined above, the Copermittees and Brown and Caldwell have consulted with technical experts in a variety of critical disciplines including Dr. Eric Stein of SCCWRP (geomorphology expert), San Diego Regional Water Quality Control Board staff, Dr. Andy Collison of Phillip Williams Associates (geomorphology expert), Dr. Khalil Abusaba (formerly of the San Francisco Regional Water Quality Control Board and currently with Brown and Caldwell – expert in statistical analysis of water quality data), and members of the San Diego HMP Technical Advisory Committee.

8.2 Technical Concepts

8.2.1 Hydromodification Concepts

As required in the Permit, the evaluation of increased erosive force is limited to the geomorphically significant flow range, which is defined between the flow associated with critical shear stress and the ten-year return flow (Q_{10}). The value of the lower flow threshold indicates the flow at which sediment erosion from the stream bed or banks begins to occur. The HMP uses two calculation tools (the low flow calculator and the SCCWRP channel assessment tool) to determine the low flow threshold based upon substrate type, channel slope, roughness, channel cross section, and other stream assessment conditions. The resulting lower flow threshold will be expressed as a multiple of the two-year return flow (Q_2):

- $0.1Q_2$ for streams with HIGH susceptibility to channel erosion
- $0.3Q_2$ for streams with MEDIUM susceptibility to channel erosion
- $0.5Q_2$ for streams with LOW susceptibility to channel erosion

8.2.2 HMP Effectiveness Validation Measures

Sediment Transport Studies. This approach monitors sediment concentration (SSC) throughout a storm event and can be used to directly evaluate the validity of a lower flow threshold for a particular stream segment. Measuring the continuous SSC to flow relationship over a range of flows allows HMP effectiveness to be evaluated based on whether or not significant post-project increases in SSC (as compared to pre-project conditions) are observed at a given flow rate. This approach is the most costly, because it involves measuring flow and SSC. The SSC measurements will involve continuous turbidity monitoring, which would include calibration of turbidity meters using stream cross-sectional sediment sampling to correlate SSC to turbidity, or an approved equivalent metric. SSC values can also be determined through a laboratory analysis using United States Geological Survey (USGS) procedures. The final analysis method, along with data collection specifications, will be determined following future discussions with the Copermittees and members of the Technical Advisory Committee. These approaches are most likely to produce information on HMP effectiveness on a relatively short time frame, provided that a sufficient range of storm event sizes can be sampled in a given year.

Flow Duration Curves. Another measure of HMP effectiveness is determining if, within the geomorphically significant flow range, the post-project flow-duration curve is comparable to or below

the pre-project flow duration curve. Flow-duration curves are monitored by installing continuous flow monitoring devices downstream of a planned project prior to development to establish pre-project conditions. If the flow monitoring facilities used for the sediment transport studies (detailed above) are located just downstream of a proposed development, then data from the sediment transport studies can be used for the pre-project flow duration data. This approach is consistent with the draft SCCWRP monitoring framework, which recommends stream flow monitoring to be provided just downstream of a hydromodification mitigation management device. Post-development mitigated flow duration monitoring data is analyzed to evaluate whether significant changes in the flow-duration curve have occurred. This monitoring approach can also be used to validate sizing factors for LID and extended detention best management practices (BMPs). Depending on the range of rainfall events encountered in a particular year, monitoring of flow-duration curves can help develop pre-project conditions and evaluate post-project effectiveness on a relatively short time scale (i.e., 2-3 years each).

Channel Incision and Widening. The most obvious measure of stream degradation is to physically measure the pre-project and post-project cross sections, and determine if the channel is incising and / or widening. This is accomplished by conducting geomorphic assessments and channel surveys downstream of a planned development before and after construction. In addition to physical measurements, comparison of current and historical photos, aerial photography, and site inspection for signs of channel degradation can provide important supporting evidence. The labor for conducting such an assessment at a single location is lower compared to the effort needed to conduct sediment transport studies. Costs are driven by the number of sites assessed, as well as the need for establishing pre-project trends (e.g., rate of pre-project channel incision per year). Although this monitoring approach is the most direct measure of whether stream degradation is occurring, it is difficult to use the method to differentiate between existing geomorphic effects and post-project geomorphic effects. To do so would require a long-term baseline of pre-project channel incision and widening rates along with post-project monitoring. To capture the range of annual rainfall conditions encountered in Southern California, decades of information are generally recommended to quantify pre-project baseline trends. Therefore, while baseline data will be collected and be useful for future comparison analyses, this monitoring plan focuses on validation measures likely to provide meaningful data within 2-5 years. It is possible that tentative conclusions may be reached regarding channel incision and widening at the conclusion of the 5-year monitoring plan. Finally, it should be noted that the Copermittees will centralize stream assessment information collected as part of project development processes. This information may be used for future channel condition assessments and will be utilized by the Copermittees to the extent practicable. While such stream assessment information will not be required for all Priority Development Projects, it would be required for all projects proposing the use of stream rehabilitation mitigation measures (e.g., constructed channel widening, drop structures) and for projects using lower flow thresholds in excess of 0.1Q₂. The Copermittees are currently considering other requirements for pre-project stream assessments, including project size, contributing impervious area cover, and receiving channel material.

8.2.3 Temporal and Spatial Variability of Monitoring Locations

Temporal Variability. As noted above, the single most important factor affecting the temporal variability inherent to measuring stream degradation is variable inter-annual rainfall frequency and intensity. Droughts in California can last years, with little to no rainfall occurring in Southern California. During El Nino years, anomalously high storm frequencies and intensities can result in sudden geomorphic changes. Rainfall intensity also varies intra-annually. However, if a sufficient

range of storm intensities is encountered in a particular year, then short duration monitoring approaches, such as flow-duration curves and sediment transport studies can provide some information on HMP effectiveness on shorter timescales.

Spatial Variability. Sampling an adequate variety of channel susceptibility types, along with a reasonable number of replicates within for each susceptibility type, is important to capture the range of watershed conditions present in the permit coverage area. Other important factors that affect stream responses to hydromodification include channel grade, watershed area, vegetated cover, and stream sinuosity. In addition to channel and watershed features, location within the watershed is an important consideration. Monitoring stations should be located in the watershed headwaters just downstream of a development project of sufficient size, so that hydromodification effects from the proposed development can be isolated for comparison purposes to the maximum extent practicable. Upper watershed sites provide more definitive measures of HMP effectiveness because they can more directly correlate effects to specific development projects. Middle watershed and lower watershed sites would be influenced by confounding variables such as mass wasting and impacts from natural tributary confluences and other existing development projects, including phased developments over many years, in the watershed. Therefore, middle and lower watershed monitoring sites would require much more time to assess overall program effectiveness. However, the Copermittees will attempt to utilize data from concurrent water quality monitoring programs to develop a database of middle / lower watershed flow data. Specifically, monitoring station located in middle to lower watershed locations will be identified for the two proposed channel susceptibility types. While the San Diego HMP has been written to require onsite hydromodification flow controls at each applicable new development and redevelopment site, thus minimizing the potential for cumulative watershed impacts as a result of new development and redevelopment, monitoring station locations will be selected, where possible, to include the effects of multiple upstream developments. If possible, one replicate monitoring station may be located in the receiving stream of a watershed containing future urban infill projects. The Copermittees would request that such data be considered by the RWQCB in future discussions regarding the appropriate level of existing impervious area percentage for determining an urban infill exemption. The concept of providing hydromodification effectiveness measurements in the watershed headwaters is supported by SCCWRP. Research by SCCWRP has shown that hydromodification effects of a development project become muted with increasing distance from the development site (defined by SCCWRP as the Domain of Effect). To the extent practicable, monitoring locations detailed in the Monitoring Plan will be distributed throughout the Permit coverage area Hydrologic Units to provide for geographic and climatic variability across San Diego County.

8.3 Recommended Approaches to Assess Effectiveness

Selection of HMP effectiveness assessment monitoring techniques is subject to two primary constraints. The schedule constraint involves the RWQCB's desire to have information on HMP effectiveness prior to re-issuance of the Municipal Separate Storm Sewer System (MS4) Permit for San Diego County, currently scheduled for 2012. This schedule constraint creates an added "practicality" issue, since it is unlikely that meaningful data can be acquired in such an abbreviated timeline. While the monitoring plan detailed in this memorandum extends for five years, interim data may be provided to the Regional Board to assist with development of the next Permit.

The budget constraint involves the San Diego County Copermittees' limited resources for monitoring. Given the fact that the Copermittees are currently committed to a \$2,500,000 annual regional water quality monitoring plan effort, and given the current economic climate in which multiple local municipalities have been forced to reduce both budget and staff, expansion of existing monitoring mandates requires significant financial consideration and analysis. Thus, the Copermittees are compelled to evaluate how to develop the best possible monitoring approach to evaluate HMP effectiveness within the available budget.

Details of the monitoring plan are above and beyond details of the existing regional water quality monitoring effort. Wherever possible, the Copermittees will seek opportunities to utilize relevant data from the existing water quality monitoring efforts to achieve an economy of scale. The Copermittees will also ensure there is no duplication of effort between the two monitoring programs.

This monitoring plan focuses on using continuous monitoring data to obtain the maximum amount of data regarding sediment transport and flow duration monitoring. It is the opinion of the Copermittees that acquisition of continuous data at a statistically justified number of monitoring locations is more valuable (from a data analysis standpoint) as compared to obtaining a finite number of isolated runoff events from more monitoring locations.

Considering the constraints and technical approach detailed above, the following approaches are recommended for the revised HMP Monitoring Plan.

- **Monitor effectiveness using Sediment Transport and Flow Duration Studies.** As noted above, continuous sediment transport and flow duration studies can provide direct measures of HMP effectiveness on a relatively short timescale. These studies are important to verify HMP assumptions about the lower flow thresholds and to verify flow duration design criteria is being achieved. Development of the sediment transport studies would also provide stream cross section data, as well as photographic evidence, that could serve as a baseline for future stream morphology comparisons.
- **Monitor the Upper Watershed.** Upper watershed monitoring is recommended to eliminate confounding lower watershed variables that would skew the analysis and minimize the potential for reaching meaningful conclusions.
- **Monitor Replicates of Two Channel Susceptibility Types.** In the development of the San Diego County HMP, receiving streams will be classified into one of three channel types, pursuant to a State Board-funded study conducted by SCCWRP. The stream classification system is consistent with the analysis, findings, and tools developed in the SCCWRP study and classifies streams into the following stream susceptibility categories:
 - HIGH susceptibility
 - MEDIUM susceptibility
 - LOW susceptibility

Monitoring locations should be selected from HIGH and MEDIUM susceptibility channel segments.

- **Monitor three replicates and one reference station for each susceptibility type.** Providing three replicates of each channel susceptibility type would begin the characterization of the range of conditions present in San Diego County. The reference monitoring station associated with each channel susceptibility type would be located in a watershed for which no upstream development

(existing or future) is anticipated. Data from the reference stations can be used to supplement pre-project condition data obtained at the replicate sites, since the amount of pre-project condition data that can be obtained at such sites is dependent on the land development process. Providing three replicate stations balances the need to characterize spatial variability against the cost of monitoring and provides the data needed to estimate the median and range of the lower flow threshold for a given susceptibility type, or to estimate the standard deviation of an average value.

8.4 Summary and Conclusions

The revised Monitoring Plan, scheduled for implementation over a 5-year period, will include the following specific activities:

Baseline Monitoring Plan Requirements:

- Development of QAPP (to be provided to Regional Board staff for review and comment)
- Rainfall gauge analysis and installation
- Rainfall gauge, stream gauge, and HMP facility outflow station inspection and maintenance (Fiscal Year 2012 through 2016)
- Annual data analysis (2012 – 2016)
- Reevaluation of the Monitoring Plan after review of findings from Statewide HMP Monitoring Technical Advisory Group and review of final SCCWRP Hydromodification Monitoring Report (interim report to be submitted in 2013)
- Report preparation (final report to be prepared in 2016)

Channel Assessments:

- Initial geomorphic assessment at each monitoring location (to determine stream susceptibility type – 2011-2012)
- Baseline cross section surveys at each monitoring location (2011-2012)
- Annual geomorphic assessments at each monitoring location (to assess channel condition and response - 2012 – 2016)
- Cross section surveys (after 5 years) at each monitoring location (2016)

Sediment Transport Analysis:

- Flow and sediment monitoring station installation
- Continuous pre-project, post-project and reference station flow, sediment and rainfall data collection (2012 – 2016)

Flow Duration Analysis:

- HMP facility outflow monitoring station installation
- Continuous post-project HMP facility outflow data collection (2013 – 2016)